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Bioactive Components in Seagrasses: A Novel Biomedicine

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Abstract

Seagrasses are also utilized as an alternative or supplementary medicine to treat various pathological conditions, including muscle aches, wounds, abdominal pain, indigestion, hangover, and mental disorders. There is, however, no comprehensive collection of existing research on their ethnopharmacological uses, nutritional value, pharmacological propensities, and bioactive components. Consequently, the focus of the study is on elaborating on the phytochemical composition and biological properties of various seagrass species, such as antioxidant and antibacterial activity. The phytochemical substances isolated from different seagrasses show various biological activities, including cytotoxicity against cancer cell lines, anti-human immunodeficiency virus (HIV), antibacterial and skin regeneration characteristics. Seagrass research has a critical gap that this review addresses. However, the mechanism of action for compounds with high biological activity has not been thoroughly explored, while technical developments in biological assays have not been adequately addressed. Finally, this study summarises the bioactive components in seagrasses and their properties to use as biomedicine.

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Introduction

Traditional practitioners have long used medicinal and herbal plants to treat a wide range of illnesses in the context of primary healthcare. Researches into the phytochemicals found in medicinal plants are currently underway, as 80% of the world's population relies on these therapies to manage various diseases (Kim *et al.*, 2021). Research in marine plants' pharmacology is still minimal, even though the marine environment is home to a wide range of organisms that could originate from bioactive molecules (Kim *et al.*, 2021).

Seagrasses are halophytes, rooted marine angiosperms that can complete their life cycles even if they are immersed in water for long periods. They are the only flowering plants that have recolonized the seafloor, and their presence helps to ensure food security while also helping to slow the effects of climate change. Millions of marine creatures depend on seagrasses, and the plants themselves aid in sediment stabilization. Several vulnerable species, including dugongs, turtles, and sea horses, use them as a feeding and nesting site. Sea cucumbers, sea urchins, starfishes, clams, and sponges are all common inhabitants in seagrass beds. There are 72 known species of seagrass in the world. Studies on the chemical components and relative food value of seagrasses were sparked by the relatively low levels of direct grazing. Seagrasses have been used to cure many diseases, including fever, skin disorders, muscle aches, wounds, and gastrointestinal issues, as tranquilizers for infants. Based on the scientific evidence, seagrasses have a wide range of interesting biological activities, including antibacterial, antiparasitic, antimalarial, vasoprotective, anti-inflammatory, antioxidant, anti-HIV, anti-aging, and antialgal effects (Nuissier *et al*., 2008).

Phytochemical Analysis

Extensive research has been done to determine the presence of various chemical substances in the seagrasses. Phenolic substances are extensively diversified in marine plants and attributed to several biological functions. Examples of natural products isolated from *Zostera marina L.* (eelgrass) include the flavone sulfates, the sulfates of luteolin, diosmetin, and apigenin, the disulphate of luteolin, and several non-sulfated phenolic acids, such as p-coumaric, ferulic, vanillic, and gentisicacids (Table 1). *Halophila ovalis*, *H. beccarii,* and *H. pinifolia* could combat bacterial infections. *Halodule pinifolia* showed the most efficacy against all pathogens, while *Cymodocea rotundata* was found to have a minor antifouling effect against the bacterial strains.

Table 1: Bioactive compounds in seagrasses and their biological activities

Bioactive molecules	Seagrasses	Biological activity
Rutin	*T. ciliatum*	Antioxidant, Antiviral and Cytotoxicity against cancer cell lines
Asebotin,	*T. ciliatum*	Antioxidant, Antiviral and Cytotoxicity against cancer cell lines
3- hydroxyasebotin	*T. ciliatum*	Antioxidant, Antiviral and Cytotoxicity against cancer cell lines
Quercetin-3-O-ß-D-xylopyranoside	*T. ciliatum*	Antioxidant, Antiviral and Cytotoxicity against cancer cell lines
Catechin	*T. ciliatum*	Antioxidant, Antiviral and Cytotoxicity against cancer cell lines
Apigenin	*E. acoroides*	Antifeedant, antibacterial, and antilarval activities
Cymodienol	*C. nodosa*	Antibacterial activity against methicillin-resistant (MRSA) strains
Thalassiolins A (luteolin 7-O-ß-D-gluco- pyranosyl-20 -sulfate)	*T. testudinum, T. hemprichii*	Antifouling activity, Anti-HIV activity
Thalassiolins B	*T. testudinum, T. hemprichii*	Anti-HIV activity, antioxidant and skin- regenerating activities
Thalassiolins C	*T. testudinum*	Anti-HIV activity
Thalassiolins A (luteolin 7-O-ß-D-gluco- pyranosyl-20 -sulfate)	*T. testudinum*	Antifouling activity
Cinnamic acid	*P. oceanica*	Antifouling activity
Coumaric acid	*P. oceanica, Z. marina, T. testudinum, H. pinifolia, T. hemprichii*	Antioxidant activity
Caffeic acid	*P. oceanica, Z. marina, T. testudinum, T. hemprichii, T. ciliatum*	Antioxidant, Antiviral and Cytotoxicity against cancer cell lines
Stigmasta-4,22-dien-6b-ol-3-one	*E. acoroides*	Antifeedant
Stigmasta-4,22-diene-3,6-dione	*E. acoroides*	Antibacterial and antilarval activities
Stigmast-22-en-3-one	*E. acoroides*	Antifeedant
Stigmasta-5,22-dien-3-O-β-D-glucopyranoside	*E. acoroides*	Antibacterial and antilarval activities
Daucosterol	*E. acoroides*	Antifeedant
Hexacosyl alcohol	*E. acoroides*	Antibacterial and antilarval activities
p hydroxy-benzaldehyde	*E. acoroides*	Antifeedant
Deoxycymodienol	*C. nodosa*	Antibacterial activity against methicillin-resistant (MRSA) strains
Isocymodiene	*C. nodosa*	Antibacterial activity against methicillin-resistant (MRSA) strains
Nodosol	*C. nodosa*	Antibacterial activity against methicillin-resistant (MRSA) strains

Data obtained from Kim *et al*. (2021)

Antimicrobial Properties

Deoxycymodienol, isocymodiene, nodosol, and briarane diterpenes were isolated from the organic extract of *Cymodocea nodosa* and evaluated for their antibacterial activity against multi-drug resistant pathogens, including methicillin-resistant *Staphylococcus aureus* and the rapidly growing mycobacterium (*Mycobacterium phlei, M. smegmatis* and *M. fortuitum*) that are resistant to antibiotics. Nodosol was the most effective of the four new identified metabolites in terms of an antibacterial activity assay. *E. acoroides* and *Halophila minor* seagrass extracts were tested for their antibacterial properties against marine pathogens and saprophytes. Extracts from *E. acorioides* demonstrated considerably greater antibacterial action against *P. bacteriolytica, S. aggregatum,* and *D. salina* than extracts from *H. minor*. Analysis was carried out on three seagrass species for antibacterial activities against human pathogens: *Staphylococcus aureus*, *Bacillus cereus, Bacillus subtilis, Escherichia coli, Salmonella paratyphi, Salmonella typhimurium* and *Micrococcus luteus,* among others (Table 2). Methanolic and ethyl acetate extracts were the most efficient at destroying bacteria. The antifeedant, antibacterial, and antilarval properties of the chemical constituents of the ethanol extracts were studied. It was discovered that eleven pure substances, comprising four flavonoids and five sterols, have strong antifeedant, antimicrobial, and antilarval properties (Kannan *et al.*, 2013). *Halophila stipulacea, Halodule pinifolia,* and *Cymodocea serrulata* seagrasses were assessed for their antibacterial properties, and the methanol extract of *H. pinifolia* showed the greatest activity.

Table 2: The pharmacological activity of seagrasses and their effect

Pharmacological activity	Type of Extract	Species	*in vivo/ in vitro*	Model
Antimicrobial	Aqueous methanol extract	*E. acoroides, T. hemprichii, H. pinifolia, S. isoetifolium, C. serrulata, C. rotundata, C. nodosa, R. cirrhosa*	*In-vitro*	*S. aureus, Vibrio cholerae, Shigella dysentriae, Shigellabodii, S. paratyphi, P. aeruginosa, K. pneumoniae*
	Hexane, chloroform, methanol	*H. stipulaceae, H. pinifolia, C. serrulata*	*In-vitro*	*S. aureus, V. cholerae, Shigella dysentriae, Shigella bodii, S. paratyphi, P. aeruginosa, K. pneumoniae*
	Hexane, chloroform, methanol	*H. stipulaceae, H. pinifolia, C. serrulata*	*In-vitro*	Phytopathogens - *Macrophominaphaseolina, Collitotrichumcapsic*i, *Fusarium* sp., *Aspergillus flavus*, *Pseudomonas aeruginosa*
	Chloroform, ethyl acetate, ethanol and hexane	*H. ovalis, C. serrulata, H. pinifolia*	*In-vitro*	*E. coli, Enterococcus faecalis, Corynebacterium, Bacillus subtilis Pseudomonas aeruginosa, Klebsiella pneumonia,* Methicillin Sensitive *Staphylococcus aureus,* Methicillin Sensitive *Staphylococcus saphrophyticus,* Methicillin Sensitive *Staphylococcus epidermidis*
	Ethyl acetate and hydrophilic (water-soluble)	*E. acorioides, H. minor*	*In-vitro*	*Lindrathalassiae, Dendryphiella salina*
	Petroleum ether, chloroform, ethyl acetate, acetone, methanol water	*C. serrulata, H. ovalis, Z. capensis*	*In-vitro*	*Halophytophthora spinosa, Schizochytriumaggregatum, Pseudoaltermonas bacteriolytica*
	Methanol extract	*S. isoetifolium*	*In-vitro*	*Bacillus cereus, B. megaterium*
	Petroleum ether, Chloroform fraction, butanol fraction	*S. Isoetifolium, H. ovalis, H. pinifolia*	*In-vitro*	*B. megaterium, Proteus vulgaris, Streptococcus lactis, Staphylococcus aureus, Aspergillus niger, M. anisopliae*
	Methanol, hexane extract	*E. acoroides, C. nodosa, P. oceanica, Z. noltii*	*In-vitro*	*Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumonia*

Table 2: Continue...

Pharmacological activity	Type of Extract	Species	*in vivo/ in vitro*	Model
	Ethanol, methanol extract	*H. pinifolia, C. serrulata*	*In-vitro*	*Candida albicans, Aspergillus niger*
	Methanol, ethanol, butanol, water, acetone extracts	*C. rotundata*	*In-vitro*	*Flavobacterium* sp., *Cytophaga* sp.
	Ethanol, methanol, acetone, dichloroethane	*C. serrulata, S. isoetifolium*	*In-vitro*	*S. paratyphi, Shigella* sp., *S. mutants, S. aureus, P. fluorescens*
	Diethyl ether, acetone, methanol extracts	*H. ovalis, H. pinifolia*	*In-vitro*	*Acenetobacter* sp., *S. typhii*
	Ethyl acetate: methanol (1:1) extract	*T. testudinum, H. wrightii, S. filiforme, H. decipiens, R. maritima*	*In-vitro*	*Micrococcus* sp., *Shigella sonii, V. cholerae, Staphylococccus* sp., *Proteus vulgaris, P. mirabilis, P. aeruginosa, Salmonella paratyphi-B*
	Lipid and water soluble phenolic extracts	*H. ovalis, H. beccari, H. pinifolia*	*In-vitro*	Fish pathogens - *Bacillus subtilis*
	Ethanol extract and fractions	*C. serrulata*	*In-vitro*	*Aeromonas hydrophila, Vibrio parahaemolyticus, Serratia* sp., *V. harveyii*
	Ethanol extract and fractions	*C. serrulate, T. testudinum*	*In-vitro*	*E. coli, Staphylococcus,* sp., *Salmonella* sp.
	90% Aqueous methanol	*C. rotundata*	*In-vitro*	*B. cereus, Bacillus circulans, Bacillus pumilus, Pseudomonas vesicularis, Pseudomonas putida*
Larvicidal	Methanol extract	*H. ovalis*	*In-vitro*	Human pathogens Brine shrimp bioassay
	Petroleum ether, Chloroform fraction	*S. Isoetifolium, H. ovalis*	*In-vitro*	Brine shrimp bioassay
	Aqueous ethanol	*S. isoetifolium, C. serrulata, H. ovalis*	*In-vitro*	Aedes aegypti larvae
Cerium Binding Activity	Pectin	*Z. marina, Phyllospadixi watensis*	*In-vitro*	Can be used as the removal of radioisotopes from the human body
Anti-inflammatory	Methanol extract, Hexane fraction, DCM fraction, Sub fraction H5	*Z. japonica*	*In-vitro*	*In-vitro*
Antiviral	Isolated compounds	*Thalassia testudinum*	*In-vivo*	HIV integrase inhibition test
	Methanol/ toluene (3:1) extract	*C. nodosa, P. oceanica, Z. noltii*	*In-vivo*	Herpes simplex virus, type I
	70% Aqueous ethanol	*T. hemprichii*	*In-vitro & In-vivo*	(HSV) cultured in kidney cells of monkey (CV-l), vesicular stomatitis virus (VSV) in kidney cells of hamster (BAK)
	70% Aqueous ethanol	*T. hemprichii, H. pinifolia*	*In-vitro*	
	Antimitotic	Methanol/ toluene (3:1) extract	*In-vitro*	Encephalomyocarditis virus
Antimitotic	Methanol/ toluene (3:1) extract	*C. nodosa, P. oceanica, Z. noltii*	*In-vitro*	(EMCV)
Cytotoxic	Methanol/ toluene (3:1) extract	*C. nodosa, P. oceanica, Z. noltii*	*In-vitro*	Vero cells, Kidney cells of monkey (CV-1)

Table 2: Continue...

Pharmacological activity	Type of Extract	Species	in vivo/ in vitro	Model
	Aqueous methanol extract	*H. pinifolia, S. isoetifolium, C. serrulata, C. rotundata*	*In-vivo*	*Brine shrimp bioassay*
Antioxidant	Pectin	*Z. marina*	*In-vivo*	Lipid peroxidation
	Pectin	*Z. marina*	*In-vitro*	Ferric reducing antioxidant power
	Pectin	*Z. marina*	*In-vivo*	Lipid peroxidation
	Ethanol extract	*E. acoroides*	*In-vitro*	TAA, DPPH, FRAP assay
	Aqueous methanol	*E. acoroides, T. hemprichii, H. pinifolia, Syringodium isoetifolium*	*In-vitro*	TLC antioxidant assay
	Methanol extract	*Halodule pinifolia, Halophila ovalis, S. isoetifolium, T. hemprichii, C. serrulata*	*In-vitro*	Radical scavenging activity
	Ethanol extract	*E. acoroides, H. ovalis, H. ovate, H. stipulacea, T. hemprichii, S. isoetifolium, C. serrulata, H. pinifolia*	*In-vitro*	TAA, DPPH, FRAP assay
	Methanol, ethyl acetate, n-hexane	*T. hemprichii, C. rotundata, E. acoroides, S. isoetifolium*	*In-vitro*	DPPH radical assay
	Methanol extract	*H. ovalis*	*In-vitro*	Radical scavenging assay
Antidiabetic, antioxidant and vasoprotective	Ethyl acetate fraction	*P. oceanica*	*In-vivo*	Glucose tolerance test, Liver
Haemolytic activity	Aqueous methanol extract	*E. acoroides, T. hemprichii, H. pinifolia*	*In-vivo*	Human erythrocyte

Data obtained from Kim *et al*. (2021)

Antioxidant Properties

Marine plants and animals have a wide range of fascinating biological characteristics. Natural antioxidants have been isolated from various plants, including oilseeds, a cereal crop, vegetables, spices, and herbs. An abundance of antioxidant molecules can be found in seagrasses. A 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical assay on the isolated elements of the four seagrasses taken from the Gulf of Mannar to evaluate antioxidative characteristics showed that antioxidant activities were comparatively stable in all seagrasses tested (Kannan *et al.,* 2013). *Posidonia oceanica*, a plant native to the western Mediterranean, demonstrated enhanced enzyme activity for antioxidant GST (Glutathione Sulfotransferase).

A wide range of bioactive metabolites may be found in seagrasses, which are an important source of varied metabolites from the natural world (Table 1 and 2). There were two diarylheptanoids found in the *Cymodocea nodosa* plant, cymodiene and cymodienol, which were both found to be potent cytotoxic agents (Table 1). *Thalassia testudinum* yielded three anti-HIV compounds: Thalassiolins A, B, and C. The ethyl acetate fraction of *Z. marina* yielded apigenin-70-b-D-glucoside, chrysoeriol, and luteolin. It was found that these chemicals had antioxidant and anti-aging characteristics. The cyclitol free L-chiro-inositol (LCI) was isolated from the *Syringodium filiforme*, which is a very unusual natural occurrence. Seagrass detritus *Zostera noltii* and *Zostera marina* were evaluated as a new zosteric acid and rosmarinic acid source, while Chicoric acid was found in the leaves of *Posidonia oceanica* and Syphonosid in *Halophila stipulacea*.

Conclusion and Future Perfectives

Researchers found that seagrasses produce a wide range of nutrients and bioactive compounds, including antioxidants, antibacterials, and cancer-fighting agents. For example, the Caribbean seagrass *Thalassia hemprichii* and *Thalassia testudinum* both contained powerful cytotoxic and anti-HIV properties, respectively, in the form of the thalassiolins A and B. Seagrass metabolites may give important leads for creating future drugs. A lack of information on seagrasses means further research is needed to confirm empirical results. Furthermore, a scarcity of enzymatic and in vivo investigations on chronic diseases, such as diabetes, inflammatory disorders, and skin-related maladies, was discovered following a thorough literature search. As a result, additional research into the therapeutic potential of seagrasses is essential. Natural products obtained from seagrasses should be tested in animal models for safety and efficacy before being tested in clinical trials to create new medicines.

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